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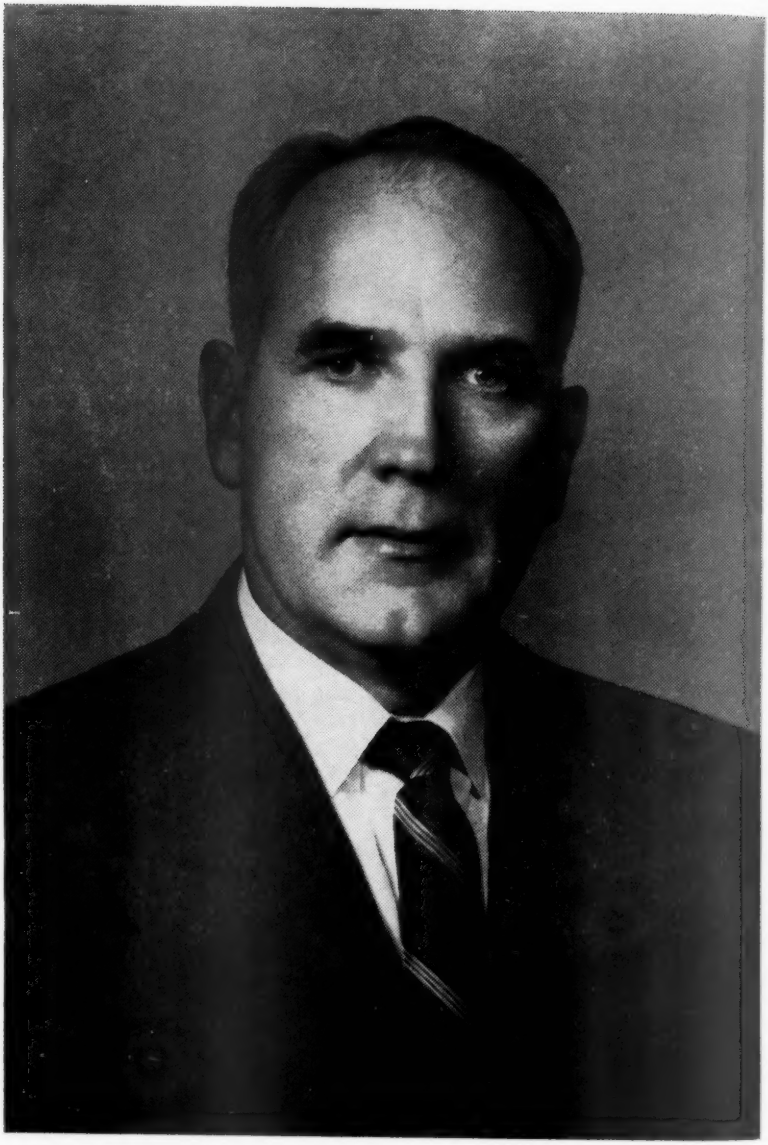

THE VIRGINIA JOURNAL OF SCIENCE

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Boyd Harshbarger

An Appreciation

In 1949 the Council of the Virginia Academy of Science decided to re-establish as the official organ of the Academy the Virginia Journal of Science. The first problem to be met was the appointment of an Editor-in-Chief. One man seemed to be preeminently qualified for this task, and so Dr. Boyd Harshbarger, then the President of the Academy was asked to serve. Dr. Harshbarger accepted without hesitation, and for the past five years has guided the affairs of the Journal. With the able assistance of Dr. Horton H. Hobbs, Jr. as Technical Editor, twenty numbers of the Journal were published during this time, and they stand as a tangible evidence of Dr. Harshbarger's service to the Academy. In addition, he has managed its business affairs so that the Journal has not only become self-supporting but has been able to set aside a reserve fund.

During this period Dr. Harshbarger's work as Chairman of the Department of Statistics of the Virginia Polytechnic Institute had been increasing and he found it necessary to submit his resignation as Editor-in-Chief, effective at the 1955 Annual Meeting. The Council has accepted this resignation with regret. The Virginia Academy of Science owes to Dr. Harshbarger a debt of gratitude for the unsparing manner in which he has devoted himself to his editorial duties. His efforts in behalf of this Journal have helped provide the impetus to carry it on and to continue its record as an organ for the publication of research by members of the Academy.

—IRVING G. FOSTER

On the Nature of Insect Resistance to Insecticides

J. M. GRAYSON AND D. G. COCHRAN

Virginia Polytechnic Institute

During the past forty-five years there have been many cases of insects exhibiting remarkable ability to adjust to the efforts of man to bring them under control by chemical poisons. Although Melander (1914) is generally considered to have first reported the occurrence of resistance in insects, it appears that this phenomenon was observed earlier by Smith (1897). During the period from 1914 to 1944 a number of insects showed definite evidence of being difficult to control with chemical insecticides that formerly were effective. In the last ten years there has been an increase in the number of reported cases of insect resistance to insecticides, so that the development of so-called resistant strains is currently one of the most serious problems in applied entomology. Many factors are probably involved but certainly it would seem that the more widespread use of contact. residual-type insecticides during the last decade is at least partially responsible.

An analysis of resistance in insects reveals a complex of independent and interacting factors which rather logically can be classified as physiological, behavioristic, and genetical. The purpose of this paper is to discuss briefly the subject of insect resistance to chemical insecticides from these standpoints, and to present certain apparent facts or ideas about resistance that perhaps are not generally understood. No attempt is made to review the complete literature on insect resistance; instead, selected references pertinent to the various discussions are employed. Babers (1949) and Babers and Pratt (1951) have published critical reviews of the literature up to 1951.

DEFINITION OF TERMS

The term "resistance" is employed when an insect population consistently exhibits greater survival from exposure to a chemical insecticide than

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[1]The junior author completed work for the Doctor of Philosphy degree from Rutgers University in October, 1954; now in military service.

Editor's Note: We are pleased to present this invited review article by Messrs. Grayson and Cochran.

*Paper received March 1, 1955.

was originally the case. The term is used in the broad sense without regard to the mechanism involved in producing the resistance. The word "tolerance" is restricted to those cases where the chemical insecticide actually enters the body tissues of the insect but fails to kill the insect. Survival is usually dependent upon the ability of the insect to store the insecticide at some harmless location, to render it relatively non-toxic through biochemical action, or to develop a substitute for the physiological system affected. It would seem that the term "immunity" has no place in the various phenomena associated with insect resistance to insecticides. Certainly in the serological sense there is no immunity involved; at least the writers know of no evidence of insecticides exerting antigenic action resulting in the formation of antibodies.

PHYSIOLOGY OF RESISTANCE

Resistance to Arsenicals.—Hough (1934; 1943) has shown the difference between resistant and non-resistant strains of the codling moth to be one of general vigor, or "power of recovery" inherent in the individual. This difference can be demonstrated in the partially developed embryo, but it is most marked in the fully developed embryo or the newly hatched larva, and it disappears to a large extent in fully fed larvae. It is manifested by an increased ability to enter fruit sprayed with lead arsenate or non-arsenical insecticides, and also by increased efficiency of newly hatched larvae in attacking the fruit. On the other hand, Haseman and Burk (1929) and Haseman and Meffert (1933) found that codling moth larvae from resistant strains were no more successful than non-resistant larvae in surviving tests in which they were fed on drops of arsenious oxide solution placed in apple dents, or sodium arsenate or acid lead arsenate administered orally into the alimentary canal. These experiments would seem to disprove the existence of any real tolerance to arsenic in resistant strains of the codling moth; instead, resistance is apparently dependent upon the selection of a strain with sufficient vigor to survive adverse conditions until entry into the apple can be made without getting the poison.

While not directly pertinent to this argument, it is of interest at this point to mention the unsuccessful attempt by Campbell (1926) to induce a detectable tolerance to arsenic in individual silkworms. These tests were conducted by administering orally a number of sublethal doses of neutral sodium arsenate solution at intervals during larval development. Also in this connection, Schwartz (1923) has concluded that acquired tolerance to arsenic has not been convincingly demonstrated in man. The "arsenic

eaters" of Styria consumed enormous doses of solid arsenious oxide but they were in reality taking sublethal doses of soluble arsenic because most of the relatively insoluble arsenious oxide passes through the alimentary canal unchanged.

In the above two examples the gradual development of tolerance in the individual is involved. On the other hand, a different phenomenon would seem to be functioning in the development of most resistant strains of insects. Here the individual usually either survives or perishes from an initial exposure to the chemical poison, and only those individuals which survive contribute progeny to the next generation. Thus it is a case of population selection rather than the gradual acquisition of tolerance in the individual. This is not meant to imply that tolerance is absent in population selection; instead inherent resistance or tolerance is presumed to be the basis for selection.

Resistance to HCN. —It has been shown that both resistant and non-resistant strains of the California red scale and the black scale exhibit "protective stupefaction" to hydrogen cyanide (Gray and Kirkpatrick, 1929; Hardman and Craig, 1941; Lindgren, 1938). By this is meant that when first exposed to a sublethal concentration of HCN in air, followed by a lethal concentration, more scales are able to survive than when the reverse procedure is followed. There is some controversy as to the significance of this mechanism but, in general, it appears that protective stupefaction operates differently in the two strains with the resistant strain being able to utilize this mechanism in a manner to avoid being killed during the normal period of fumigation (Lindgren, 1938; Hardman and Craig, 1941). Regardless of its importance, however, protective stupefaction does not appear to constitute the entire escape mechanism because it has been reported that both resistant and non-resistant strains of scales are able to close the spiracles when exposed to HCN. This is of importance because with the non-resistant strain tested the spiracles remained closed only very briefly, whereas with the resistant strain they remained closed at least 30 minutes (Hardman and Craig, 1914). It is obvious that such a factor could be of importance, although Quayle (1942; 1943) does not believe it is, and has postulated an "inherent resistance within the organism." Likewise, Yust (1952) stated that tracheal closure does not cause resistance, nor does any other reaction which he was able to observe. Instead, Yust and Shelden (1952) have postulated that susceptibility to HCN is associated with a high degree of dependence on heavy metal-containing enzyme systems for tissue oxygen requirements, whereas resistance to HCN is associated with a high degree of dependence on metal-free, autoxidizable respiratory enzymes. This hypothesis is based on their finding that, among other things, oxygen consumption is depressed least in a super-resistant strain, intermediate in a resistant strain, and to the greatest extent in a non-resistant strain of scale insects after they were exposed to HCN. Although this evidence is very suggestive, it must be taken as indirect or circumstantial evi-

dence for the mechanism of resistance. It does not rule out the possibility of other factors being involved.

Resistance to DDT. —A review of the physiological studies on DDT has been published by Chadwick (1952). He discussed the various facts and theories on the mechanism for DDT intoxication in insects, and pointed out that much remains to be learned before the mode of action of this poison will be entirely clarified.

Some facts relative to the physiological nature of DDT resistance have been obtained. For example, significant correlations have been demonstrated between survival of treated insects and the conversion of DDT by these insects to its relatively non-toxic derivative, DDE (Perry and Hoskins, 1950, 1951; Sternburg and Kearns, 1950; Sternburg *et al.*, 1950; March and Lewallen, 1950). It has been shown that this detoxification, at least in houseflies, is produced by the action of an enzyme (Sternburg *et al.*, 1953; Sternburg *et al.*, 1954). This is probably not the entire mechanism of resistance to DDT, but there seems to be little doubt that DDT does readily enter the insect body (Lindquist *et al.*, 1951; Tahori and Hoskins, 1953). It also appears to be well established that in resistant strains of houseflies, DDT is prevented from exerting its lethal effect at least partially through a biochemical conversion. In such cases it would seem that true tolerance to the poison was demonstrated.

Analysis of Information. —From the above three examples of insect resistance to insecticides some interesting facts are evident. In all three cases the overall result is the same — *i. e.*, resistance to an insecticide. In each case, however, the means by which this resistance was achieved is different. With the codling moth resistance is apparently due to an increase in the general vigor of the resistant strain, there being no evidence of the development of tolerance to arsenic. In scale insects the question of the mechanism of resistance to HCN is still undecided. It seems almost certain, however, that HCN is entering the body of the insects but fails to kill the resistant ones. According to the definition employed herein, this represents true tolerance to HCN. If it should subsequently be proven that this resistance is attributable to a metal-free enzyme system, it will mean that resistance was achieved by the selection of a strain of insects capable of physiologically avoiding the effects of this poison. In the case of resistance to DDT true tolerance has been satisfactorily demonstrated, in that DDT is directly attacked by the resistant insects and converted to relatively non-toxic products. This apparently represents the first instance where detoxification has played a significant role in resistance.

BEHAVIORISTIC RESISTANCE

Hough (1943) found that the newly hatched codling moth larvae from resistant strains showed less tendency to drop or wander from the fruit than similar larvae from non-resistant strains. He felt that this could be one of the factors contributing to the difference between a resistant and a

non-resistant strain, although it could be considered as a result rather than a cause of the essential difference between strains.

In a review of resistance in insects affecting public health, Hess (1953) calls attention to occurrences of resistance which might be attributed to changes in insect behavior. The resistance of *Musca domestica* to DDT in the Americas, and that of *M. vicini* in Africa and in Israel, is thought to be partially attributable to changes in insect behavior. The existence of behavioristic resistance to DDT in populations of *Anopheles* mosquitoes in the Americas and in Africa is suspected. In some cases it is manifested by a hyperirritability to DDT which causes the insect to become more restless and spend less time than normal upon treated surfaces. In insect populations containing both zoophilic and anthropophilic strains, it is thought that DDT treatments produce a higher kill of the latter with a resulting shift in the population towards the strain preferring animals other than man. This, of course, makes satisfactory control difficult because it leaves a reservoir of insects around those areas in which it is feasible to attempt control measures.

At the present time, one of the most intriguing features of this type of resistance is its mere existence. It is obvious from the preceding remarks that much remains to be learned about the details of this phenomenon. It should be particularly interesting to see how it is related to the other more thoroughly studied phases of resistance. In any case, it serves to re-emphasize the complexity of the whole problem.

GENETICS OF RESISTANCE

Resistance to Arsenicals and HCN. —Hough (1928, 1934) made reciprocal crosses and back crosses between strains of the codling moth which differed in their ability to enter apples sprayed with lead arsenate. The results obtained have been interpreted by Brown (1951) as indicating autosomal, multiple-gene inheritance.

Dickson (1941) showed that resistance to HCN fumigation exhibited by the California red scale is inherited as a simple, sex-linked factor. This was later confirmed by Yust *et al.* (1943).

Resistance to DDT. —The information on the inheritance of resistance to DDT in the house fly is somewhat contradictory. Bruce and Decker (1950) made reciprocal crosses between resistant and non-resistant strains and from their results concluded that autosomal, multiple-gene inheritance is involved. On the other hand, results obtained by Harrison (1951) in the F_1 and F_2 progeny from reciprocal crosses indicated one factor, autosomal inheritance with the factor for susceptibility being incompletely dominant. A more critical study of these results by Harrison (1953) revealed that the character inherited as a simple Mendelian factor is in reality resistance to paralysis or "knockdown" rather than resistance to DDT-induced mortality. When Harrison studied the latter character she also found evidence of a complex inheritance in house flies. In addition, Jonhston *et al.* (1954) have

presented evidence for the involvement of a cytoplasmic factor in the inheritance of DDT resistance in the house fly. They concluded that this factor apparently constitutes the entire mechanism for resistance. It is extremely difficult to reconcile this and certain other rather sweeping conclusions made by these workers with the data which they presented.

The genetics of resistance in *Drosophila* is currently being investigated by a number of workers. Tsukamoto and Ogaki (1953) found some evidence of resistance to DDT in certain mutant strains of *Drosophila melanogaster* although they had never been exposed to DDT. They found no evidence of DDT resistance being linked with the sex chromosomes. Further work indicated one or a few major genes of DDT resistance to be located on the second chromosome near the gene for vestigial. It is not clear if they consider this to be the entire mechanism. Other workers have found DDT resistance in *Drosophila* to be inherited in a complex, multiple-factor manner (King, 1954; Crow, 1954; Pimental *et al.*, 1954).

Cochran *et al.* (1952) have shown that the inheritance mechanism for DDT resistance in the German cockroach is complex and that both chromosomal and extra-chromosomal factors seem to be involved. The genetics of resistance to chlordane in the German cockroach is currently being investigated[2]. The evidence indicates that resistance to chlordane in this insect may involve a slightly different genetic mechanism from that of resistance to DDT. The results obtained from F_1 and F_2 progeny of reciprocal crosses, back crosses, and progeny from paired matings within strains, have indicated that the factors for resistance to chlordane in the German cockroach are carried on the autosomes. This resistance probably involves the genes at several loci but there is no evidence of sex-linkage or extra-chromosomal factors.

Analysis of Information. —The existing knowledge of the genetics of resistance in insects is somewhat fragmentary but there is presumptive evidence of the following points: (1) a lack of dominance in resistance, as indicated by the intermediacy of progeny from reciprocal crosses of resistant and non-resistant strains, and (2) that, with the exception of the red scale, resistance is a multiple-factor character, as shown by its continuous distribution in the F_2 and back crosses. A discontinuous distribution should result in segregation into definite Mendelian ratios.

It should be pointed out, however, that it is extremely difficult to ascertain the resistance of an individual insect; in fact it is usually the resistance of the population as a whole which is determined. Because of this, it is conceivable that a ratio resulting from two or three genetic factors might be masked by the techniques currently in use. It must be admitted that mortality is not an entirely satisfactory genetic criterion, particularly in view of the phenotypic variation which normally occurs within a population. There is also a possibility that the development of resistance is in

[2]Unpublished data obtained in the laboratory of the senior author.

reality a selection for heterozygotes because, superficially, the results obtained would be substantially the same as those which have been reported. A more plausible explanation, however, would seem to be that resistance is dependent on a number of independent non-allelomorphic genes probably not less than three, and that these genes are cumulative in their effect. In such cases the highest degree of resistance would result from homozygosity for resistance at each of the loci involved. This still permits that heterozygous individuals could exhibit considerable resistance. It is conceivable that a number of heterozygous loci might compare favorably with a smaller number of homozygous loci in producing resistance. Such a difference could explain why resistance is more rapidly lost in some strains than in others when selection is discontinued. In addition, it should also be mentioned that in the German cockroach and in the house fly there is evidence for the involvement of cytoplasmic factors in the inheritance of DDT resistance. It is not clear how these factors work in either case, but the authors suggest that they are transmitted through the female and act in a complementary manner with the chromosomal mechanism. These cytoplasmic factors also appear to be under the control of the nuclear genes because in both animals there are examples of loss of the apparent effect when genes for resistance and genes for susceptibility are both present. In any case, it appears that cytoplasmic inheritance in resistance does exist and should be taken into account in future experiments dealing with this subject.

SOME OTHER CONSIDERATIONS

Homozygosity in Resistance. —When frequency of homozygotes is plotted against gene frequency in a random breeding population, a curve such as that shown in Figure 1 is obtained (data from Lush, 1945, p. 67). It is a theoretical presentation involving one gene pair, and ignores the possibility of mutations or other factors which might lower the frequency of the favored allele as homozygosity is approached.

If the degree of resistance to insecticides in insects is dependent to any appreciable extent upon a homozygous condition for genes favorable to resistance, as the authors believe, then the above mathematical concept should help to explain why resistance in an insect population develops slowly at first but more rapidly after the gene frequency has been increased through selection. Furthermore, it shows why complete homozygosity for resistance would be difficult to attain. This is true because of the diminishing number of individuals exposing the unfavorable allele to selection as the frequency of the favored allele approaches unity. For example, when the favored allele has reached a frequency of 0.9, individuals homozygous for this allele constitute 81 per cent (0.9^2) of the population, those homozygous for the unfavored allele only 1 per cent (0.1^2), and the remaining portion of the population is heterozygous. This principle can be extended to cases involving more than one locus. It is readily apparent

that the existence of a situation involving multiple factors would considerably complicate the process of selection for favored genes. Thus it is evident that homozygosity for resistance would be extremely difficult to attain in cases where genes at several loci are involved.

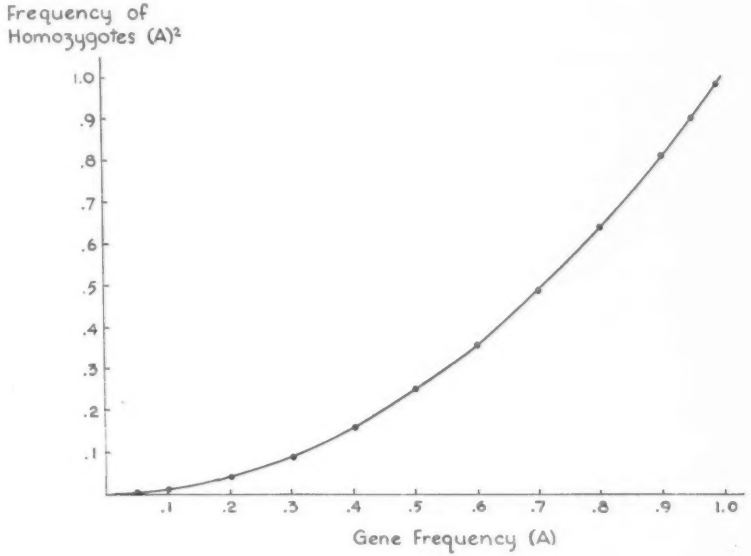

FIGURE 1. —Relation of gene frequency to frequency of homozygotes in a random breeding population.

Rate of Inbreeding. —It has been shown that some insecticidally selected insect strains are composed of individuals with lower biotic potential and smaller size than those in normal strains (Grayson, 1953, 1954). An occurrence of this kind might appear to be an expected result of inbreeding, but such an assumption is hardly feasible after analysis. The formula for determination of rate of inbreeding in an entirely closed population is as follows:

$$\left[\frac{1}{8M} + \frac{1}{8L}\right] \times 100 = \text{percentage of inbreeding}$$ (Lush, 1945), where M is the number of males and L is the number of females in each generation that are effective in producing offspring.

From this it can be determined that the rate of inbreeding would equal 0.5 per cent each generation if 50 effective pairs were allowed to mate at

random, and it would be only 2.5 per cent if as few as ten pairs were involved. In view of the number of breeders that are likely to be used in the development of most selected strains, it would hardly seen logical to consider inbreeding as the principal factor responsible for lowered biotic potential and smaller size in selected strains.

Types of Variation. —Beard (1952a; 1952b) has recognized the following three sources of variation in response of an insect species to a toxic material: (1) variation in response by the individual insect, (2) variation in response by individuals about the group mean at a particular time, and (3) variation of the means of test groups. Also, he has pointed out that contributing to these phenomena is a dynamic versus a static type of variation, inherent in at least some species, which should be considered in evaluating the response of an insect to a chemical poison. Further work (Bliss and Beard, 1953) has shown that certain of these hypotheses are substantiated by experimental data.

The existence of these types of variation in insect response certainly seems plausible, although they might be expected to exert varying degrees of influence in different insect species. In those cases where little resistance results from exposure to a poison over a considerable period, it might be logical to assume that a high degree of variation is present and that the technique of selection has been reduced to minimum effectiveness. On the other hand, resistance has developed sufficiently rapidly in many insect species from the use of standard toxicological procedures that such methods would appear to be effective in avoiding the influence of variation.

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Monoecious Tendencies in the Crayfish, *Cambarus longulus longulus* Girard[1]

W. H. LEWIS

Department of Biology; University of Virginia

When Hay (1905) recorded the presence of gonads of both sexes in one individual of *Orconects limosus* (=*Cambarus affinis*), it was the first published account of crayfish hermaphroditism. Although he observed a well developed ovary with maturing oocytes, the rudimentary testis and vasa deferentia contained no spermatozoa and presumably the former lacked spermatids and spermatocytes. In two individuals of *O. propinquus propinquus* (=*Cambarus propinquus*), a further example of hermaphroditism was observed by Turner (1935) who noted scattered "patches of ovarian tissue" in an otherwise typical testis. It can be assumed that these specimens were capable of producing spermatozoa; however, in the absence of an histological description of these ovarian patches, the extent of their development remains obscure. Though male and female elements were associated in the gonads of the three specimens, no evidence was presented by either Hay or Turner illustrating the existence of both oocytes and spermatozoa in any one animal.

While working with *C. longulus longulus* in an attempt to ascertain what effect the removal of the eye stalk might have on the spermatogenetic cycle, another instance of a monoecious tendency was discovered in one of the control animals. In a sexually mature, form I male with no unusual secondary sexual characteristics collected at Piney River, Nelson Co., Virginia on Nov. 11, 1954, thirteen oocytes were observed in the three lobes of the testis. With the possible exception of the proximal acini in each lobe, where the greater number of oocytes occurred, their distribution was apparently at random. Since young oogonia are difficult to distinguish from spermatogonia or primary spermatocytes, and further, since the proximal portions of the testicular lobes mature first, it is probable that there were additional potential oocytes in the distal portions of the lobes.

The oocytes vary from 26-109μ. in diameter with a corresponding range in nuclear diameter from 21-60μ. The arithmetic means of the diameters of thirteen oocytes and nuclei are 42μ. and 28μ., respectively. These are distinguished readily from the primary spermatocytes by their larger size and by the sizes of their nuclei – the diameter of the primary spermatocytes average 20μ. and that of the nuclei, 14μ. In most cases the developing oocytes are small enough so that other cells occur within the acinus. Those oocytes, however, with a diameter of 100μ. or more tend to fill the entire

[1]The author acknowledges the guidance afforded by Dr. Horton H. Hobbs, Jr., of the University of Virginia, in the preparation of this paper.
*Paper received June 12, 1955.

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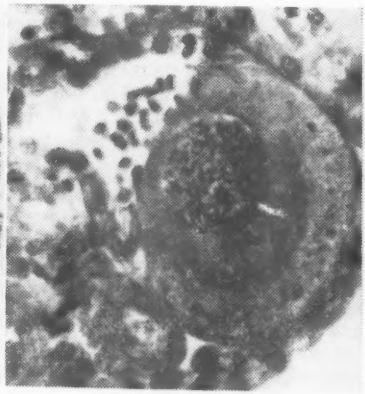

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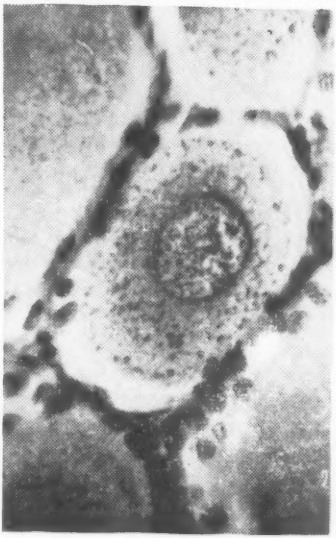

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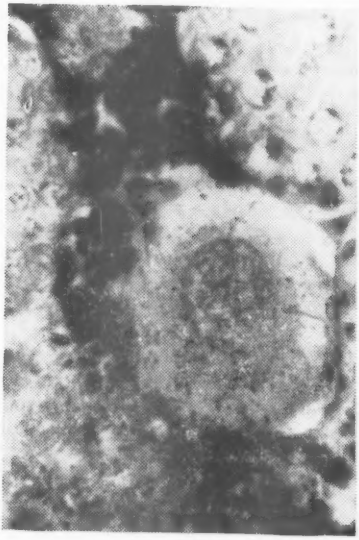

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acinar space. Figure 1 illustrates such an oocyte 109μ. in diameter almost filling the acinus and apparently pushing the spermatozoa into a tubule as it increases in size. A clearer illustration of the close association between the oocyte and the spermatozoa is afforded by Figure 2.

Soon after their initiation, oogonia in the testis are similar to the spermatogonia in their circular outline, but with development, they assume a more oval shape. This compares with the maturation of oogonia in the ovary of *C. longulus longulus*. The ovarian oocyte in Figure 3 measures 149μ. in length and in all morpohological respects, it resembles the oocyte in the testis.

On Dec. 27, 1954, the testis of another form I male from the same population was found to contain twenty-one oocytes. Mature spermatozoa were abundant in the vas deferens. Oocytes again occurred in all three lobes of the testis, occasionally two or three occupying a single acinus. The cells range from 32-117μ. in diameter, with an arithmetic mean of 50μ., and all appear morphologically similar to the oocytes in the ovary as well as to those in the previously mentioned testis. Figure 4 shows an oocyte completely filling an acinus surrounded by other acini that contain spermatogonia or primary spermatocytes; in addition, darkly stained nuclei of the epithelial cells and connective tissues associated with the acini and tubules may be observed.

Approximately 120 specimens from the Piney River population have been examined histologically and of these, only two were found with this anomaly. There is insufficient evidence at this time to hazard an estimate on the percentage of crayfish with an "ovo-testis" at this locality. In the testes of more than 100 additional specimens of the same species from the Charlottesville area no monoecious tendencies were observed.

There is one point of interest concerning the position of the germinal epithelium in the testis. Finding oocytes proliferating from cells of the acinar walls would indicate that it is the epithelial lining of the acinus, and hence the tubule (Word 1954), which has the additional potential of giving rise to gametes.

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The Nesting and Ovarian Eggs of the Dusky Salamander, *Desmognathus f. fuscus* Raf., in Southeastern Virginia

JOHN THORNTON WOOD, FRANK G. CAREY, AND ROGER H. RAGEOT
University of Virginia, College of William and Mary, and Norfolk Museum of Arts and Science

The literature contains no information on the time and duration of nesting of *Desmognathus f. fuscus* Raf. in southeastern Virginia, or on the ecology and natural history of this nesting. Similarly, there has been no previous study of behavior of the female attending the nest, of the relationship between the number of large ova (ready for deposition) in the ovaries of a gravid female and her size, and of the changes in large ova dimensions through the year. Reported here is the first description of a nest of the dusky salamander in southeastern Virginia with ecological and natural history observations; a study of the relationships between the snout-vent lengths of 34 gravid females and their large ova complements; a comparison of left ovary contents with those of right ovaries to detect any unilateral tendencies; and a study of the conditions of the ova in 115 females gathered throughout the year.

On August 23, 1953 a single compact nest of *Desmognathus f. fuscus* eggs was found beneath a small log lying on a moist mud flat about five yards from the nearest surface water. The female darted into a tunnel in the log as soon as the nest was uncovered. This behavior is at variance with reports in the literature that nests are attended by females that were found curled around the egg masses and made no effort to escape (Robertson and Tyson, 1950). The female guarding the eggs is "undoubtedly the mother" according to Wilder (1913), but as far as the authors can determine it has never been verified by marking females and their large ova that they actually do attend the eggs they deposit. The female that attempted to escape when the nest was exposed was found to have a recently ingested (little digested) annelid worm in her stomach, and the egg group she had been attending contained embryos having total lengths of 10 mm., evidence that they were between three and four weeks old. Obviously the female had devoted part of her time of "attending" the nest to feeding herself. This behavior is sharply contrasted with that of *Hemidactylium scutatum* females, found attending their eggs, in which no stomachs contained recognizable food items. (Wood, 1951).

*Paper received August 17, 1954

The egg group consisted of 34 embryos. In Massachusetts nests of *Desmognathus f. fuscus* contain from 14 to 28 eggs, averaging 20 (Wilder, 1907); in New York, from 12 to 26 eggs, averaging 17 (Bishop, 1941); in Pennsylvania, from 22 to 34 eggs were found in 44 nests (Pawling, 1939) and in Ohio, 17 to 36 eggs, averaging 26.3 (Wood and Fitzmaurice, 1948). Nests contain fewer eggs south of Virginia—in the range of *D. f. brimleyorum* Stejneger and intergrades between this subspecies and the northern one. In Georgia a nest contained six eggs (Neill and Rose, 1949); in North Carolina six nests contained from 14 to 20 eggs (Robertson and Tyson, 1950), and two nests contained 17 and 22 eggs respectively (Eaton, 1953). The Virginia nest contained an egg complement near the maximum reported in the literature.

The nest, found near a drainage ditch near Suffolk, Nansemond County, was a moist hollow beneath a small log imbedded in mud, and the cavity containing the eggs might well have been formed by the turning movements of the female prior to egg deposition; females are known to "excavate" nests in this way (Wilder, 1913). Usually nests are immediately adjacent to water areas, and never more than two or three feet from water

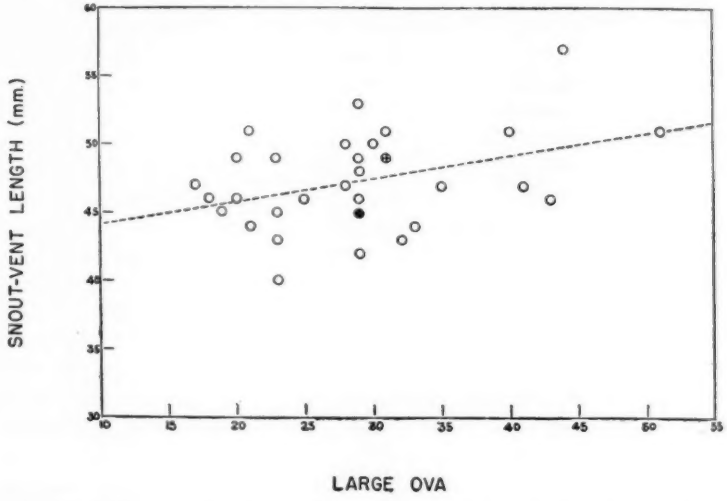

FIGURE 1. The relationship between the large ova complements of 34 *Desmognathus f. fuscus* from Southeastern Virginia, and the snout-vent lengths of the females. The open circles indicate one specimen; dot, two specimens; crossed circle, three specimens. [1]

1. The lines in Figures 1 and 2 were fitted to these data by eye.

(Wilder, 1913). This nest was in a crevice which extended down into the mud from beneath the log, and would have been submerged if surface water were on the mud flat. Since females of this species do not lay eggs beneath water, it is evident that the nest was originally placed 15 feet from water just as it was when discovered later. Placing their eggs out of water, yet adjacent to it, is evident of less primitive nesting habits according to Noble (1931); the terrestrial location of this nest indicates that another step in the evolution of this species is in progress.

Wilder (1913) considers that the number of large ova in a gravid female approximate the number of eggs found in a nest. Dunn (1926) suggests the ova complement is related to the size of the female, and Bishop (1941) noted that although a large complement of ovarian eggs may equal in number the eggs in a nest, it usually exceeds it. Thirty-four gravid dusky salamanders were collected under logs and slabs beside brooks in James City and York counties in February and April, 1949 and 1950 — ap-

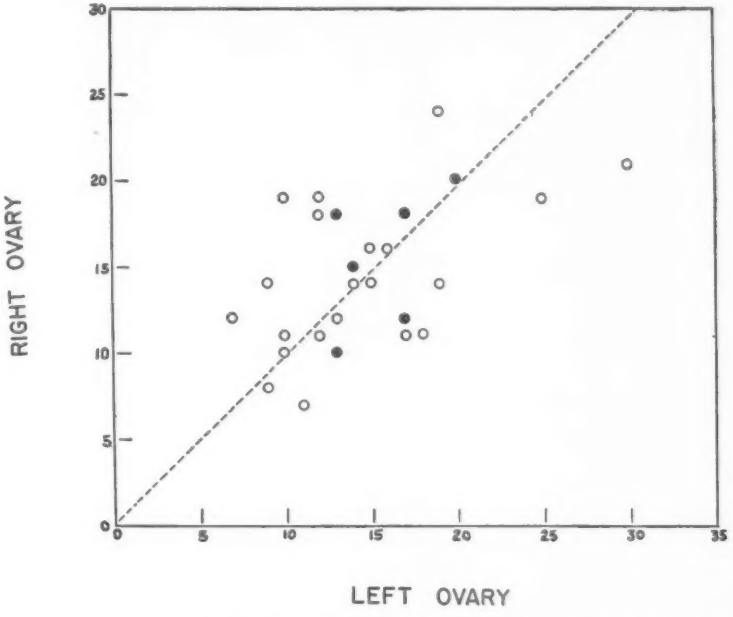

FIGURE 2. The relationship between the numbers of large ova in the right and left ovaries of 34 *Desmognathus f. fuscus*. The open circles indicate one specimen; dots, two specimens. [1]

proximately five and three months prior to the egg laying season in this area, respectively. The oviducts of all of the specimens were unmarked by the distension and convlutions which indicate that egg deposition has been partially completed. Snout-vent measurements of these females ranged from 40.0 to 57.0 mm., averaging 47.4 $\pm$ 3.4 mm. Large ova ranged in number from 17 to 51, averaging 29 $\pm$ 8. Figure 1 shows the relationship between size of females and their complements of large ovarian eggs. For females of a specific size (e.g., snout-vent length 46 mm.) the number of ovarian eggs may vary widely (*e. g.*, 18 to 43 large ova in this case). Wilder (1913) reported 10 or 11 large ova in each ovary as a consistent finding in her dissection of gravid *fuscus*. No such consistent complement regardless of the size of the female has been noted.

In elongated animals such as salamanders there is frequent longitudinal modification of organs, and in some cases one of a pair of organs becomes vestigial. Comparison of the ovary contents, Figure 2, shows that this is not true of the ovaries in *fuscus*.

The time and duration of nesting in dusky salamanders is poorly understood. Some reports of nests in the literature are based upon observations made at time of larval emergence, and others shortly after egg deposition. For this reason it has been believed that the egg-laying season is an extended one. Examination of the ovaries of 115 females gathered during the year indicates the egg-deposition season is a brief one. Large ova in females collected from October to February contained deutoplasm which was distinctly yellowish, in contrast to the whitish translucent contents of the many small ova; their dimensions ranged in 9 specimens from 1.0 to 1.5 mm., and no evidence of growth during this winter period was evident. Ova were larger in specimens collected in February, March, and April, and in 49 specimens it was noted they increased in size to a maximum of 2.5 mm. Twelve specimens collected in June and July contained large ova which reached a maximum diameter of 3.0 mm.; none had started spawning. All 39 females examined in August had completely spawned the large ova complements. No large ova were detected in specimens collected and examined in September, and not until October was yellow deutoplasm observed. From this it appears that nesting occurs in late July or early August in southeastern Virginia.

ACKNOWLEDGMENT

The studies to which these observations are incident were supported by a grant from the A.A.A.S. through the Virginia Academy of Science, to which groups grateful acknowledgment is hereby made.

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The Land Snails of Hanover, Henrico, and Chesterfield Counties, Virginia[1]

JOHN B. BURCH[2]

University of Richmond

A preliminary list of the Mollusca of Hanover County was published by J. B. Burch (1952) in which twenty-five species and sub-species of land snails were reported. P. R. Burch (1950) listed six species of land snails for Henrico and Chesterfield counties, and J. B. Burch (1954) reported twenty-four species and sub-species for Henrico County. *Triodopsis obsoleta* (=*Triodopsis hopetonensis obsoleta*) (Pilsbry) was reported by Hubricht (1953) as being an introduced form in Richmond.

This paper is the result of a two-year investigation of the distribution and relative abundance of land snails in this area of Virginia.

DESCRIPTION OF THE AREA

Hanover, Henrico, and Chesterfield counties cover an area of 1179 square miles in east-central Virginia. The area is limited on the north by the North Anna and Pamunkey Rivers and on the south by the Appomattox River. The eastern boundary is for the most part marked by the Pamunkey, James, and Appomattox Rivers, and Matadequin and Turkey Island Creeks. The western boundary is in part formed by Tuckahoe and Skinquarter Creeks.

Two physiographic regions, the Coastal Plain to the east and the Piedmont Plateau to the west, merge along a line which crosses each county, dividing Hanover and Henrico counties roughly into equal halves and Chesterfield County into an area about four-fifths of which lies in the Piedmont Plateau. This fall zone is several miles wide, with no definite boundaries.

The Piedmont province is a region of hard rocks and rolling topography. The soils have been derived mainly from granite and gneiss formations and comprise primarily the Durham and Cecil series (Bloomer, 1938). The Cecil series is the most widespread type of soil occuring over the Piedmont region. It is a gray, red, or brown loam with a red clay subsoil. What was formerly a plateau is now so deeply eroded by drainageways that little of the plateau surface remains. In its eastern part the Piedmont Plateau has an average elevation of about two hundred feet above sea level, but it rises gradually toward the west. Most of the streams which cross it flow

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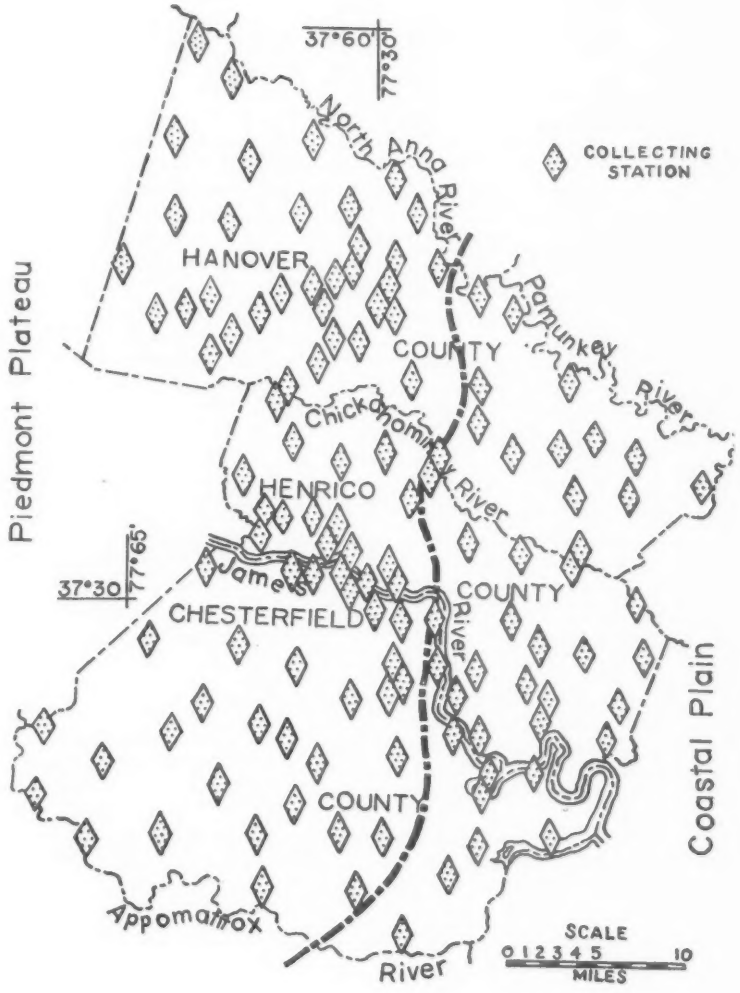
[1]This represents a portion of a M. S. thesis submitted to the Department of Biology, University of Richmond, June, 1954.

[2]Present address: Department of Zoology, University of Michigan.

* Paper received December 6, 1954


37°60'
77°30'
North Anna River
COLLECTING STATION
HANOVER
COUNTY
Pamunkey River
Chickahominy River
HENRICO
COUNTY
James River
37°30'
77°65'
CHESTERFIELD
COUNTY
Piedmont Plateau
Coastal Plain
Appomattox River
SCALE
0 1 2 3 4 5 10
MILES

through narrow valleys in rocky channels.

The Coastal Plain is a region of sand, clay, and other soft materials, laid down on an eastward-sloping floor of granite and other crystalline rocks and dips gradually to the east. The soils differ from those of the Piedmont in their loose structure, lack of loaminess, the predominance of sand, and the frequent occurrence of water worn gravel throughout the soil profile. For the most part the Coastal Plain consists of a wide plateau trenched by broad, terraced valleys of numerous streams. The larger streams are tidal estuaries as far inland as the zone in which the hard rocks rise from under the deposits of the Coastal Plain and become high enough to cause rapids. As the rise of these rocks is usually fairly steep the stream valleys narrow in a short distance into rocky gorges which mark the change from the Coastal Plain to the Piedmont province.

The major portion of the two regions is well drained by several rivers and their tributaries. The most extensive drainage system is the James River which flows through the central part of the area, marking the boundary between Henrico and Chesterfield counties. The largest tributary of the James in this area is the Appomattox River. The drainage system to the north consists primarily of the North Anna, Little, New Found, Pamunkey, Chickahominy, and South Anna Rivers.

The climate is generally mild with an average annual temperature of 12° C. Because of a difference in elevation of almost three hundred feet, the average temperature of the region near the western boundary is slightly cooler than that of the district near the eastern boundary; however, there is no apparent difference in the precipitation. The annual precipitation averages about 43 inches (Latimer and Beck, 1913), and the wet months occur during the growing season in the spring and summer. The first killing frost comes usually about the first of November and the last severe frost is usually during the early part of April.

DISTRIBUTION OF SPECIES

Although no species in this area is *abundant*, i.e., "observed in numbers every time search is made for it in the proper habitat" (Dice, 1952), according to the scale of abundance commonly employed by ecologists, several species are common and generally distributed throughout the area. Several species have been found at only one station and may be introduced forms or epibiotics. Others are of frequent abundance and generally distributed and some are apparently restricted to a particular physiographic province.

Common species are arbitrarily defined as those found in sixty-five per cent or more of the total number of samples; *numerous* or *frequent* species in twenty-five to sixty-five per cent of the samples; *occasional* or *scarce* species in five to twenty-five per cent of the samples; and *rare* species in less than five per cent of the collections. Two species are common, five

frequent, fifteen occasional, and twelve rare.

In the section to follow is an annotated list of species with notes on distribution and abundance.

ORDER STYLOMMATOPHORA
SUBORDER SIGMURETHRA
FAMILY ENDODONTIDAE

Anguispira alternata (Say) is found occasionally in scattered localities in Hanover and Henrico counties in hardwood forests. It sometimes occurs in lots with *Anguispira fergusoni*.

Anguispira fergusoni (Bland) is of occasional occurrence and is generally distributed over the three counties. It has been found in greatest numbers in thickly forested river valleys and has been found associated with various oak and elm communities, being most abundant in oak-elm associations. It seems to be restricted to soils very high in calcium content and is most abundant at a pH range of 6.3 - 6.7.

Helicodiscus parallelus (Say), a small, flattened, greenish-yellow snail, is common throughout the area and, although associated with all the types of plant communities where collections were made, is prevalent in oak-pine stands. It is exceeded in abundance only by *Zonitoides arboreus* (Say).

Punctum minutissimum (Lea), a minute snail, is rare and has been found in this area only in the Piedmont province, although P. R. Burch (1950) has reported it from the Coastal Plain in Norfolk County. It has been found associated with oak-elm and oak-pine communities, and only in the pH range of 6.3 - 6.7.

Discus patulus Deshayes was reported by P. R. Burch (1950) from Henrico County but was not found during this investigation.

FAMILY HAPLOTREMATIDAE

Haplotrema concavum (Say), generally considered a carnivorous species, is of frequent occurrence, and has been found in a large number of plant communities, although it is more commonly associated with oaks, maples, and willows. Ingram (1941) considers this species an omnivore rather than a carnivore and in this case the plant association may have some direct influence on distribution.

FAMILY POLYGYRIDAE

Mesodon appressus sculptior Chadwick is of rare occurrence and was found only along the James River lowlands, primarily on the Chesterfield County side of the river. It was encountered most frequently in willow and sycamore-willow communities and was associated only with soils very high in calcium content.

Mesodon thyroidus (Say), one of the larger land snails, is numerous in this area, being found most abundantly in the Piedmont, although P. R. Burch (1950) reported its occurrence in Elizabeth City and James City counties. Rehder (1949) found it "common" at Virginia Beach, Princess

Anne County. It is generally associated with woodlands having a predominance of oaks.

Stenotrema hirsutum (Say) is another species which seems generally to be restricted to the Piedmont, but has been found by P. R. Burch (1950) in Elizabeth City County. It has an occasional occurrence in the Piedmont and has been found in two localities in the fall zone. Those individuals found in Henrico and Chesterfield counties comprise a small race, averaging somewhat less than 7 mm. in diameter. S. *hirsutum* has been found in a number of oak and elm associations, most frequently in oak-pine associations. Although Lee (1952) states that in the vicinity of Ann Arbor, Michigan, S. *hirsutum* is restricted to river valleys and alkaline soils (pH range 7.5 - 8.5) this is not the case here. Its occurrence is most frequent in woodlands some distance from streams, and it has been found only in soils having a pH range of 6.2 - 7.4.

Triodopsis albolabris (Say), the largest land snail found in this area, is somewhat solitary, of occasional occurrence, and has been found only in associations in which oak is one of the dominant trees - most frequently in oak-maple communities.

Triodopsis fallax (Say) is a scarce species, and except for one station near the fall zone in the Coastal Plain was found only in the Piedmont province.

P. R. Burch (1950), however, has found it in James City County, and Hubricht (1953) has reported it from York, New Kent, Sussex, Southampton, and Franklin counties. It has been found most generally in edificarian communities.

Triodopsis hopetonensis (Shuttleworth) has been found in only one locality in Henrico County, near the James River, Va. Rt. 605, and in two localities in Chesterfield County, near the intersection of Va. Rt. 655 and Va. Rt. 659, and near the James River, Va. Rt. 746. Hubricht (1953) states that it apparently does not occur north of the James River in Virginia. Its occurrence in Henrico may be due to accidental transportation.

Triodopsis obsoleta (=*Triodopsis hopetonensis obsoleta*) (Pilsbry) has been reported by Hubricht (1953) as an introduced form in Richmond, but specimens have not been found in this study. P. R. Burch (personal communication), however, believes that polgyrid forms with aperture dentation reduced or lacking are probably the result of insufficient calcium in the diet, since laboratory culture of snails in cultures deficient in food and calcium show reduced aperture dentation. Hubricht's T. *obsoleta* may have been atypical T. *hopetonensis*.[3] *T. hopetonensis* has been found in oak, sycamore-willow, and willow associations.

Triodopsis tridentata juxtidens (Pilsbry) is generally distributed and of frequent occurrence throughout the three counties. It has been found pre-

[3]According to the large sample Mr. Hubricht gave the U. S. National Museum, Dr. J. P. E. Morrison (personal communication) thinks his "*obsoleta*" reported for Richmond is actually *Triodopsis messana*.

dominantly in oak and elm communities, and at a pH range of 5.8 - 6.2, decreasing in number as the pH increases.

FAMILY ZONITIDAE

Euconulus dentatus Sterki. — Dr. Morrison identified specimens sent to the U. S. National Museum from Falling Creek, Va. Rt. 653, Chesterfield County as *E. dentatus* and doubts if *Euconulus chersinus* (Say), a southern species, and *Euconulus fulvus* (Muller), a northern species, occur in this area of Virginia. *E. chersinus* and *E. fulvus* were previously reported from Hanover County in 1952, and *E. chersinus* from Henrico County in 1954. These previous identifications were made from descriptions given by Pilsbry (1946) and based partly on the absence of dentations in the last whorl.

Hawaiia minuscula (Binney), a species of occasional occurrence, is generally distributed throughout the area, and has been found most abundant in oak-sycamore communities and at a pH range of 6.3 - 6.7.

Retinella burringtoni (Pilsbry) was found frequently in the Piedmont region, and usually in plant associations dominated by oaks. It has rarely been observed in the Coastal Plain. The southernmost point in its range, as published, is at its type locality, Natural Bridge, Rockbridge County, Virginia (Pilsbry, 1946).

Retinella indentata (Say) is of frequent abundance and generally distributed over the entire area in association with a variety of trees. Its most common occurrence is in oak-poplar stands. *R. i. paucilirata* (Morelet) was reported in 1952 from Hanover County, but all specimens were probably atypical *R. indentata*. *R. i. paucilirata* differs from the typical *R. indentata* mainly in a slightly larger umbilicus and somewhat greater size. Although some specimens from this area fit the description of *R. i paucilirata* very well, J.P.E. Morrison identified all specimens sent from Hanover and Henrico counties as *R. indentata*. The form *R. i. paucilirata* is a southern variety, Rehder (1949) giving its northernmost record in the Coastal Plain as along State Route 170, south of Moyock, Currituck County, North Carolina. Rehder (1949) giving its northernmost record in the Coastal Plain as James River, U. S. 1, and near the intersection of Va. Rts. 667 and 690), both in the Piedmont of Chesterfield County and in different plant associations, *viz.*, sycamore-willow and oak-pine respectively. It has not been reported from any of the surrounding counties.

Ventridens ligera (Say), a large snail of occasional occurrence, is most common in the eastern James River flood plain. It was observed most frequently in association with oak-sycamore stands in the lowlands and in oak-pine stands in the higher regions. Although Rehder (1949) states that it is apparently rare in the coastal region, but common at Virginia Beach, Princess Anne County, Hubricht (1953) has reported it from Southhampton, Nansemond, and Elizabeth City counties.

Ventridens suppressus magnidens (Pilsbry) was found occasionally throughout the area except for the Coastal Plain of Chesterfield County.

Most frequently it was collected in oak and oak-pine associations and at a pH range of 5.3 - 5.7. There seems to be a local race in Hanover County different from the forms found in the two counties to the south. This local race comprises individuals in which the teeth diminish or even disappear in the fully adult stage (as they do in *V. suppressus* (typical form) (H. A. Pilsbry, personal communication). *V. gularis theloides* (Pilsbry) was reported in 1952 from Hanover County but all specimens were later identified by Pilsbry as this local race of atypical *V. suppressus*.[4]

Zonitoides arboreus (Say) is the most common and widely distributed land snail found in this vicinity. It is not restricted to woodlands but when found in plant communities is most frequently associated with oaks. It is found in the most acid and the most alkaline soils, *i.e.*, in the pH range 4.8-7.7, but most frequently in a range of pH 6.8-7.2.

SUBORDER HETERURETHRA

FAMILY SUCCINEIDAE

Succinea aurea Lea was found at five localities in the eastern part of the area along the James River. Specimens were picked from rocks near the waters edge.

SUBORDER ORTHURETHRA

FAMILY CIONELLIDAE

Cionella morseana (Doherty) was found at only one locality, near the James River, Va. Rt. 679, Chesterfield County. It was found under decaying oak, poplar, and sycamore leaves at the base of a granite cliff on soil with a pH of 6.0 and a very high calcium content.

FAMILY PUPILLIDAE

Columella edentula (Draparnuad), a scarce, solitary species, was found in both physiographic provinces in all three counties. P. R. Burch (personal communication) also found it in King William County. It has been found associated with oak-pine and maple-sweet gum stands.

Gastrocopta armifera (Say) was found at only one station, Va. Rt. 657, three miles west of Ashland, Hanover County, under and around a compost pile. It has been reported by P. R. Burch (1950) from Dinwiddie County.

Gastrocopta contracta (Say), although a scarce species, is distributed over the entire area. It is most abundant in oak and oak-poplar associations on soils with a pH range of 6.8 - 7.2. Found rarely in soils with less than very high calcium content.

Gastrocopta pentodon (Say) is rare and apparently restricted to the Piedmont region, although it is reported in the Coastal Plain from Elizabeth City County (P. R. Burch 1950). It has been found only in plant asociations abundant in oak.

Gastrocopta procera (Gould) is rare in this area, and has been found

[4]Dr. J. P. E. Morrison is of the opinion that *V. s magnidens* does not occur in Virginia. He identified material sent the U. S. National Museum from VA. 657, three miles west of Ashland, Hanover County, as *Ventridens cerinoideus* (Anthony).

at only three localities in the western Piedmont of Hanover County.

Pupoides albilabris (Adams), also a rare species, has been found in two localities in the Piedmont of Hanover County (Springfield Church, Va. Rt. 611, and Va. Rt. 657, one mile west of Ashland) and one locality in the Coastal Plain of Henrico County (White Oak Swamp Creek, Va. Rt. 802). It has been reported by P. R. Burch (1950) in Dinwiddie, Highland, and Norfolk counties. In this area it has been found associated only with oak-maple stands.

Vertigo ovata (Say) was found at several stations in the Piedmont province associated with oak-maple and oak-poplar stands. Although not found in the Coastal Plain of this area, it has been reported from Norfolk County (P. R. Burch, 1950).

FAMILY STROBILOPSIDAE

Strobilops aenea (Pilsbry) occurs frequently and is generally distributed over the entire area. This minute, dome-shaped species was found most commonly under the bark of fallen oak logs. When found in humus it was most frequent at a pH range of 6.3 - 6.7 and soil of very high calcium content.

Strobilops labyrinthica (Say), very similar to *S. aenea*, is not restricted to any particular region, but is scarce. It has been reported by P. R. Burch (personal communication) from Louisa, King William, and New Kent counties.

FAMILY VALLONIDAE

Vallonia excentrica (Sterki) was found only in the Piedmont of Hanover and Henrico counties and was rare. It has been reported from the Coastal Plain of Virginia by P. R. Burch (1950) in Norfolk County. It was found at a pH of 7.5 at the only station where soil analysis data are available for this species.

ORDER BASOMMATOPHORA

FAMILY CARYCHIIDAE

Carychium exiguum (Say), one of the smallest snails in the area (length, 1.6 mm.; width, 0.7 mm.), has been found occasionally in the Piedmont, associated only with stands where oaks are abundant. Specimens resembling *Carychium exile* Lea were also present in some lots, but recent work by Harry (1951) seems to indicate *C. exile* is merely a growth variant of *C. exiguum*.

SUMMARY

One hundred and ninety-seven collections from 123 stations have been made in Hanover, Henrico, and Chesterfield counties, Virginia, between June, 1952 and May, 1954. Thirty-four species and subspecies representing ten families and two orders have been determined and their distribution and abundance noted. Duplicate specimens have been deposited in the collections of Dr. Paul R. Burch, Rockville, Virginia, and in the United States National Museum, Washington, D. C.

ACKNOWLEDGMENTS

I wish to thank Dr. Nolan E. Rice, University of Richmond, for criticism, encouragement, and advice in the development of this problem. I am indebted to Dr. Henry A. Pilsbry, Curator of Mollusks, Academy of Natural Sciences of Philadelphia, for identifying *Gastrocopta pentodon* (Say) and *Ventridens suppressus magnidens* Pilsbry; Dr. J. P. E. Morrison, Associate Curator of Mollusks, United States National Museum, Washington, D. C., for identifying *Anguispira fergusoni* (Bland), *Euconulus dentatus* Sterki, *Retinella burringtoni* (Pilsbry), and *Retinella indentata* (Say), and for critically checking some of my material; and Dr. Paul R. Burch, formerly Professor of Biology, Radford College, Virginia Polytechnic Institute, for information concerning land snail distribution in Virginia. Grateful acknowledgement is made to the Research Committee of the Virginia Academy of Science for a research grant which helped meet the financial demands of this problem.

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News and Notes

AGRICULTURAL SCIENCE SECTION

Dr. F. D. Hansing, who has been working in cooperation with staff members of the Department of Agricultural Economics at Virginia Polytechnic Institute, was transferred by the U. S. Department of Agriculture to the University of Delaware, effective April 30, 1955.

Dr. J. S. Plaxico resigned from Virginia Polytechnic Institute March 12 to accept a position in the Department of Agricultural Economics at Oklahoma Agricultural and Mechanical College.

Mrs. Marguerite N. Horn, Instructor of Rural Sociology at Virginia Polytechnic Institute, has resigned, to be effective June 5, 1955. Her husband, Dr. Herman Horn, will become Superintendent of Roanoke County Public Schools.

Andrew Jackson Lambert, Agricultural Engineering Graduate of Virginia Polytechnic Institute, 1950, has joined the Agricultural Engineering Department Staff as Associate Extension Agricultural Engineer. Lambert served as rural representative for the Appalachian Electric Power Company at Rocky Mount, Virginia for four years. He is devoting most of his time to the Extension program in rural electrification.

Homer T. Hurst has been appointed Associate Agricultural Engineer in the Research Division of the Agricultural Engineering Department. Hurst is a native of Arkansas and received his B.S. and M.S. degrees in Agricultural Engineering at Ohio State University in 1950 and 1951 respectively. He did structures research work for the Ohio Experiment Station prior to coming to Virginia Polytechnic Institute on March first. Hurst's work at Virginia Polytechnic Institute will be on farm structures research.

James H. Strickler has been appointed Associate Agricultural Engineer to serve as Coordinator for the Virginia Farm Electrification Council, a position on the Agricultural Engineering Department Staff. Strickler received his B.S. degree in Agricultural Engineering at Virginia Polytechnic Institute in 1951 and since then had been employed in rural electrification work with T. V. A. His appointment was effective May 2.

The Virginia Farm Electrification Council reelected E. T. Swink, Head, Agricultural Engineering Department and H. W. Sanders, Head, Vocational Education Department at Virginia Polytechnic Institute, for its Chairman and Vice Chairman, respectively, for 1955-56. The annual business meeting of the Council was held in Richmond on May 11.

Dr. Robert F. Kelly has been appointed by the Animal Husbandry Department at Virginia Polytechnic Institute to direct the work in meats research and teaching. Dr. Kelly received his training at the University of Wisconsin.

Recent publications from the Biochemistry and Nutrition Department at Virginia Polytechnic Institute include the following: Nutrients in Soils and Plants. Minor Element Content of Forage Plants and Soils. *Journal of Agri-*

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cultural and Food Chemistry 3, pp. 226-229, March, 1955. N. O. Price, W. N. Linkous and R. W. Engel. Minor Element Content of Forage Plants from the Coastal Region of Virginia.*Virginia Agricultural Experiment Station Technical Bulletin* 123, *April*, 1955. N. O. Price, W. N. Linkous and R. W. Engel, Department of Biochemistry and Nutrition.

WESLEY P. JUDKINS, *Virginia Polytechnic Institute*

ENGINEERING SECTION

Mr. Tilton E. Shelburne of the Virginia Council for Highway Investigation and Research attended a meeting on May 9 in Chicago of the Working Committee on design of a test road of the American Association of State Highway Officials. On May 25 he attended a meeting of Department Chairmen of the Highway Research Board in Washington. Mr. Shelburne is Chairman of the Design Department.

Professor Lawrence R. Quarles, Assistant Dean of the Engineering School of the University of Virginia, attended the ASEE Southeastern district meeting in Knoxville, Tennessee on April 14-16. On May 25 he attended an invitational meeting at Penn. State University to discuss university nuclear reactors. This meeting was held under the auspices of the National Research Council Subcommittee on Unclassified Reactors. Professor Quarles has been instrumental in establishing the degree Doctor of Science in Engineering-Physics which was approved during May by the University of Virginia.

Professor R. E. L. Gildea of the Civil Engineering Department, University of Virginia, and Mr. Phillip Melville of the Virginia Council for Highway Investigation and Research attended the joint meeting of the Student Chapters of the ASCE at Lexington, Virginia on May 6. Professor Robert M. Hubbard of the Chemical Engineering Department, University of Virginia, attended the meeting of the AIChE held in Louisville, Kentucky in March.

Professor Robert W. Truitt of the Aeronautical Engineering Department, Virginia Polytechnic Institute, has recently completed a research project for the Air Force on "Investigation of Wedges in Transonic Flow." Dean John W. Whittemore of Virginia Polytechnic Institute attended the Industrial Management Conference on March 18 held under the sponsorship of the Virginia Manufacturers' Association, Virginia Military Institute, and Washington and Lee University. Professor Dan Frederick of the Applied Mechanics Department, Virginia Polytechnic Institute, received the Ph.D. degree in Engineering Mechanics from the University of Michigan in February.

Professor Nelson F. Murphy of the Chemical Engineering Department, Virginia Polytechnic Institute, presented a paper on "Two Film Theory in Liquid-Liquid Extraction" at the Houston, Texas meeting of the AIChE, on May 2. Professor Murphy escorted chemical engineering students to the

corrosion research laboratories of the International Nickel Company near Wrightsville Beach, North Carolina on May 20. Professor Dale S. Davis, also of this chemical engineering department, presented a paper called "Industrial Nomography" before the Engineering Drawing Division of the ASEE in Knoxville, Tennessee on January 28. Professor Davis recently had published by Reinhold Publishing Corporation a text entitled "Nomography and Empirical Equations." Professor Dudley Thomson, also of this chemical engineering department, has been awarded a grant of $4,100 by Socony-Vacuum Oil Company to support research on the effects of ultrasonic energy on mass transfer in liquid-liquid extraction.

The George Washington Engineering Award has been presented for three successive years by the Engineering Section as a result of the generous enthusiasm of various engineers throughout the State of Virginia. The inception of this award resulted from the excellent projects showing engineering ability on the part of Junior Academy members. The substance of the award is not only the scroll shown above but also a cash prize. In addition the complimentary efforts of the Senior engineers reflect themselves in counsel and encouragement for the Juniors to pursue their projects. Guidance into college or technical employment is a common result for the winner and all other contestants.

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1954

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The award committee

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Dudley Thompson
Robert D. Hubbard

Washington, Hdq

Robert N. Smith
Nelson F. Murphy
Bernard A. Niemeier

The winners of this award have been:

1952 – Gerald P. Waldberg
1953 – Floyd Wilson
1954 – Walter S. Thomas

—ROBERT M. HUBBARD, *University of Virginia*

GEOLOGY SECTION

Nearly one hundred geologists representing colleges and universities. governmental agencies and private companies participated in the joint field conference held in Harrisonburg, Virginia, May 19-22, 1955. The conference was sponsored by the Virginia Division of Geology, the Applachian Geological Society, and the West Virginia Geological Survey. The stratigraphy and structure of Pre-Cambrian and Paleozoic rocks between the east slope of the Blue Ridge and the Bergton gas field in Rockingham County were studied. One of the highlights of the conference was the trip through the Shenandoah Caverns.

Geology of Bergton Gas Field, Rockingham County Virginia, by Robert S. Young and Wilbur T. Harnsberger is being issued as Reprint Series No. 17 by the Virginia Division of Geology.

Porter J. Brown, geologist, United Fuel Gas Co. of Charleston, West Virginia, spoke to the Holden Society of Virginia Polytechnic Institute in connection with the Sixth Annual Engineering Conference held April 21-23. He emphasized practical aspects of exploring for oil and gas in the Appalachians.

Dr. R. M. Allen, manager of the French Coal Co., Bluefield, West Virginia, spoke to the Holden Society at the regular meeting held on May 10. His talk dealt with the composition and structure of certain coal beds in southern West Virginia.

Dr. Bruce Nelson will join the staff of the Virginia Polytechnic Institute Geology Department in September 1955. He will teach courses in mineralogy and geochemistery and also will devote part of his time to research in conncetion with the study of the clay deposits of Virginia.

Jonathan Edwards, Jr. is this year's recipient of the Holden Prize. The prize, a Brunton compass, is awarded annually to the Virginia Polytechnic Institute senior majoring in geology who has the highest scholastic standing. Edwards will be field assistant with The Texas Company in Montana before returning to Virginia Polytechnic Institute in the fall to work on his masters degree. Donald P. Moore was the winner of the Sophomore Achievement Award. This award, an Estwing geologic pick, is given to the Virginia Polytechnic Institute sophomore majoring in geology who from all standpoints has shown promise of contributing much to his profession.

The first *Additions to Virginia Mineral Localities* will be published by the Virginia Engineering Experiment Station, Blacksburg, Virginia, in October or November. R. V. Dietrich requests that any information concern-

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ing new mineral localities or corrections of material included in *Virginia Mineral Localities* be sent to him at the Department of Geology, Virginia Polytechnic Institute, Blacksburg, Virginia, so that they may be included in this new bulletin.

Dr. Troy J. Laswell of the geology department of Washington and Lee University will spend the summer working on photogeology for Humble Oil Co. John Alford and Alan Mixson, Washington and Lee students, will be engaged in exploration for uranium in the Yellowknife district of the Northwest Territory of Canada.

Wayne E. Moore of Virginia Polytechnic Institute will spend the summer studying the lithology and stratigraphy of the sediments of the Virginia Coastal Plain. This study is being made for the Virginia Division of Geology. Fletcher McCutcheon is stationed in Lewiston, Montana where he is employed by The Texas Company. Carl Meyertons is working for Stanolind and is stationed in Albuquerque, New Mexico. Both received their masters degrees from Virginia Polytechnic Institute in June.

—W. D. LOWRY, *Virginia Polytechnic Institute*

PSYCHOLOGY SECTION

The Virginia Examining Board for Clinical Psychologists has recently certified the following: Alvis W. Jeffreys, Jr., of Western State Hospital. Mrs. Antonía Bess Morgan of Aptitude Associates, and Jacob Silverberg of McGuire Veterans Hospital. William M. Hinton was reelected chairman of the Examining Board. William E. Harris, Chief Clinical Psychologist at McGuire Hospital, was appointed to the Board to succeed Austin E. Grigg, who has resigned his position at the University of Richmond to continue graduate work at the University of Iowa. Richard H. Henneman was reelected to the Board. Other members of the Board at the present time are Miss Catherine T. Giblette of Richmond, and Dr. Gilbert J. Rich, Director of the Roanoke Guidance Center, and present Chairman of the Psychology Section.

Several Virginia psychologists were active on the program of the first meeting of the newly organized Southeastern Psychological Association, held in Atlanta, May 22-24. Frank W. Finger was moderator of a symposium, "The Teaching of Psychology in Colleges and Universities"; Stanley B. Williams spoke on psychology in the small liberal arts college, on this same symposium; Dr. Gilbert Rich was a panel speaker on a symposium, "The Roles of Psychological Organizations", speaking on the role of the state organization. Richard H. Henneman was panel speaker representing experimental psychology on a symposium, "Research in Progress". Morris Roseman presented a paper, "The Advantages and Disadvantages of the Co-therapy Method in Group Psychotherapy – the Opinions of Co-therapists". He was also co-author of another paper on the program, "A Graphic Method for Showing Therapeutic Change by the Use

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of MMPI Scales". Dr. Gilbert Rich also presented a paper, "The Psychologist in the Community Clinic Team as Seen by a Psychiatrist". William M. Hinton and Richard H. Henneman were chairmen of the sessions on the school psychologist, and on motivation, respectively.

Arrangements are now being completed for the Fourth Annual Seminar of the Roanoke Veterans Administration Hospital to be held on October 10 and 11. The subject of this year's seminar is "The Patient, the Hospital, the Community — The Integration of the Psychiatric Hospital and the Community".

At the annual business meeting of the Richmond Psychological Association, on May 20, the following officers were elected for the forthcoming year: Robert Filer, president; Jack Silverberg, vice president; Ann Hardesty, secretary-treasurer. James T. Grayley will leave the Educational Therapy Center, Richmond, in August, to attend the University of Maryland, working toward his Ph.D. in counseling psychology. John Williams, Ph.D., University of Iowa, will join the staff at the University of Richmond in September. Charles E. Peachee, formerly psychologist at Central State Hospital, Petersburg, assumed his duties as staff psychologist at Westbrook Sanitarium, Richmond, on June 1. Mrs. Catherine Giblette recently retired from her position as chief psychologist at the Memorial Guidance Clinic in Richmond. She is continuing her psychological work in private practice.

Burton R. Wolin left the College of William and Mary February 1 to take a research position with the Rand Corporation, Santa Monica, California. Miss Ernestine Cox took his place during the past semester as acting instructor. Peter M. Guthrie of Brown University has been appointed to an assistant professorship in psychology for 1955-56. John Bare and Stanley B. Williams are continuing a research project at William and Mary this summer for the Air Force on operator efficiency as a function of scope size.

Walter A. Woods, of the Richmond Professional Institute School of Clinical and Applied Psychology, is leaving to accept a Veterans Administration appointment at Lyons, New Jersey. Other changes in the RPI staff include William R. Reeve, who is leaving at the end of the summer to accept a position at Oregon University; Robert Corder, who joined the staff as associate professor in February, will continue next year; Edwin S. Thomas, completing his Ph.D. at Syracuse University, will join the RPI staff in September.

Morris Roseman of the Veterans Administration Hospital, Roanoke, has been appointed Chief Clinical Psychologist at the Veterans Administration Mental Hygiene Clinic in Baltimore, and will assume his duties there sometime during the summer.

Dr. Frederick S. Hauser, Assistant Professor of Psychology at Hollins College, has accepted a position in New York City with George Fry and Associates as a consultant psychologist.

William M. Hinton of Washington and Lee, and Robert C. Wingfield of Converse College will be members of the Summer School staff in psychol-

ogy at the University of Virginia. Frank A. Geldard will continue to direct research on vibratory sensitivity of the skin on a contract for the Office of Naval Research. Richard H. Henneman is director of a research contract on complex decision-making behavior for the Surgeon General's Office of the Army. Frank W. Finger and L. Starling Reid have received a grant from the National Science Foundation for research on patterns of response to food and water deprivation in the rat.

Miss Hannah Davis is expected to return to the Lynchburg State Colony this summer following her leave of absence. Mrs. William McConnell is leaving the Lynchburg Guidance Center to do graduate study at the University of Pittsburgh. Miss Marjorie Brownell will return to Randolph-Macon Woman's College after a year of advanced study at the University of Massachusetts. Paul Mountjoy will be an acting member of the psychology department at Sweet Briar College during the 1955-56 session.

RICHARD H. HENNEMAN, *University of Virginia*

STATISTICS SECTION

Dr. R. A. Bradley returned to his position as Professor of Statistics at the Virginia Polytechnic Institute June 1, 1955, from Rutgers University where he was a visiting professor. He will present a series of seminars at the Southern Regional Graduate Summer Session in Statistics which will be held at the University of Florida this summer. Dr. Bradley gave a paper at the convention of the American Society for Quality Control entitled "Statistical Designs for Taste Test Panels". His papers, "Some Notes on the Theory and Application of Rank Order Statistics, Parts I and II," were published in the February and March issues of *Industrial Quality Control*. Dr. Bradley is going to Rutgers University September 10 to take part in the Rutgers All-Day Convention on Statistics.

Dr. Boyd Harshbarger and Dr. R. A. Bradley visited the Oak Ridge Institute of Nuclear Studies to discuss the progress of R. G. Cornell's dissertation and reported that definite progress is being made.

Dr. Boyd Harshbarger is teaching Design of Experiments at the Southern Regional Graduate Summer Session held at the University of Florida, Gainesville, Florida.

Dr. W. A. Thompson, Jr. will resign his position as Associate Professor of Statistics at the Virginia Polytechnic Institute June 30 to accept a position in El Paso, Texas.

Dr. R. L. Wine joined the staff of the Virginia Polytechnic Institute as an Associate Professor of Statistics on April 15, 1955. Dr. Wine studied at Bridgewater College, the University of Virginia, the University of Michigan, and received his Ph.D. degree from the Virginia Polytechnic Institute. His dissertation was entitled "A Power Study of Multiple Range and Multiple F Tests." He has published a paper entitled "Some Air War Games",

Engineering Research Institute, University of Michigan, Ann Arbor, Report No. M965 R-2.

Dr. R. J. Freund joined the staff of the Virginia Polytechnic Institute as an Associate Professor of Statistics June 1. Dr. Freund has studied at the University of Chicago and North Carolina State College. He completed and received his Ph.D. degree from the North Carolina State College. His publications include "A Statistical Investigation of the 1949 North Carolina Grain Survey"; "The Selection of Optimal Farm Enterprises: a Case Study in Linear Programming" with Dr. R. A. King; "A Procedure for Solving a Linear Programming Problem" with Dr. R. A. King.

Mr. D. P. Morton will join the staff of the Statistics Department of the Virginia Polytechnic Institute September 1, 1955. He received his formal training at the McGuire's University School and the Virginia Polytechnic Institute. Mr. Morton is a registered Professional Engineer (Mining and Mechanical) and has written numerous technical articles and papers. He has worked in Virginia and West Virginia coal fields as mine superintendent. Mr. Morton has been Chief Rating Commissioner with the Chesapeake and Ohio Railroad and has been very active in forecasting and statistical work.

Dr. J. E. Freund and Mr. Irwin Miller published a paper entitled "In Defense of Frequencies" in the *American Statistician*, April 1955.

The following members of the Statistics Section received their M.S. degrees in statistics from the Virginia Polytechnic Institute on June 5, 1955: E. L. Bombara, Leo Lynch, Kamini Patwary, A. N. Pozner, R. L. Taylor, and Dan Zakich.

Mr. Norbert L. Enrick of the Institute of Textile Technology, Charlottesville has recently published the following: "Quality Control", Second Revised Edition, The Industrial Press, N. Y.; "Quality Control through Statistical Methods; Specifically Designed for Textile Mills", Modern Textiles Magazine; "Modern Mill Controls", Modern Textiles Magazine; "Making Best Use of Sampling Inspection", Plant Administration; and "Statistical Quality Control in Textile Processing", Amer. Soc. for Quality Control, Textile Division (Copies of the latter may be obtained from Mr. Enrick.

LIONEL WEISS, *University of Virginia*